one or more alkali metals or alkaline earth metals or other transition metals, rare earth metals, or lanthanides. Additionally elements such as P and Bi may be present.

[0050] The catalyst may comprise one or more: catalyst metals, including noble metals, transition metals and combinations thereof; metal oxides, including oxides of alkali metals, alkaline earth metals, boron, gallium, germanium, arsenic, selenium, tellurium, thallium, lead, bismuth, polonium, magnesium, titanium, vanadium, chromium, manganese, iron, nickel, cobalt, copper, zinc, zirconium, molybdenum, tin, calcium, aluminum, silicon, lanthanum series element(s), and combinations thereof; composites; zeolite(s); nitrides; carbides; sulfides; halides; phosphates; and combinations of any of the above.

[0051] The catalyst may comprise an oxidation catalyst represented by the formula

$$Mo_{12}W_aBi_bFe_cCo_dNi_eSi_fK_gSn_hO_x$$

[0052] in which: a is between 0 and 5, b is between 0.5 and 5, c is between 0.1 and 10, d is between 0.5 and 10, e is between 0 and 10, f is between 0 and 15, g is between 0 and 1, h is between 0 and 2, and x is the quantity of oxygen bonded to the other elements and depends on their oxidation states. These catalysts are described in U.S. Pat. No. 6,251,821 B1 as being useful for making acrolein from propylene by oxidation. This patent is incorporated herein by reference. The catalyst may comprise an oxidation catalyst represented by the formula

$$Mo_aBi_bP_cX^1{}_dX^2{}_eX^3{}_fX^4{}_gO_h$$

[0053] wherein X^1 is V, Nb, Ta, Cr, W, Ga, Ce and/or La; X^2 is Li, Na, K, Rb, Cs, Cu, Ag, Au, Pd and/or Pt; X^3 is Sn, Pb, Sb, Bi, Te, Fe, Co and/or Ni; X^4 is Si, Al, Ti and/or Zr; a is 0 to 2; d is 0 to 2, with the proviso that the sum of a and d is at least 0.20; b is 0 to 1.5, c is 0 to 10, with the proviso that the sum of b and c is at least 0.1; e is 0 to 0.5, f is 0 to 0.5, g is 0 to 20 and h is a number different from zero which is determined by the valence and frequency of the elements different from oxygen. This catalyst is disclosed in U.S. Pat. No. 6,252,122 B1 as being useful for converting propane to acrolein. This patent is incorporated herein by reference.

[0054] The catalyst may comprise an oxidation catalyst represented by the formula

$$Mo_{12}Bi_aFe_bX_c{}^1X_d{}^2X_e{}^3X_f{}^4O_n$$

[0055] where X^1 is Ni and/or Co; X^2 is Tl, an alkali metal and/or an alkaline earth metal; X^3 is Zn, P, As, B, Sb, Sn, Ce, Pb, and/or W; X^4 is Si, Al, Ti and/or Zr; a is from 0.5 to 5; b is from 0.01 to 5, and in one embodiment from 2 to 4; c is from 0 to 10, and in one embodiment from 3 to 10; d is from 0 to 2, and in one embodiment from 0.02 to 2; e is from 0 to 8, and in one embodiment from 0 to 5; f is from 0 to 10; and n is a number which is determined by the valency and frequency of the elements other than oxygen. These catalysts are disclosed in U.S. Pat. No. 6,395,936 B1 as being useful for the oxidation of propylene to acrolein. This patent is incorporated herein by reference.

[0056] The catalyst may comprise an oxidation catalyst represented by the formula

$$[Bi_nA_aO_x][(100-z)\%\ E_eFe_fNi_gMo_mO_y+z\%\ SiO_2]$$

[0057] wherein A is at least one element selected from the group consisting of B, P and Mo; E is at least one element having the atomic valence of 2; when m is 1, n is 0.001 to 3, a is 0 to 3, e is 0 to 3, f is 0.01 to 5, g is 0.1 to 5, and z is 0 to 90; and x and y are numbers such that the valence requirements of the other elements for oxygen in the core and shell catalytic phase, respectively, are satisfied. This catalyst is disclosed in U.S. Pat. No. 6,410,800 B1 as being useful for the oxidation of propylene to acrolein. This patent is incorporated herein by reference.

[0058] The catalyst may comprise an oxidation catalyst represented by the formulae

$$Mo_{12}Co_{3.5}B_{1.1}Fe_{0.8}W_{0.5}Si_{1.4}K_{0.05}O_x$$

[0059] or

$$Ni_{2.1}Co_{3.5}Fe_{2.6}P_{0.43}Bi_{1.0}Mo_{9.3}Mn_{0.15}Cr_{0.09}Ba_{0.07}Zr_{0.0012}K_{0.07}O_x$$

[0060] where x is the quantity of oxygen bonded to the other elements and depends on their oxidation state. These catalysts are disclosed in U.S. Pat. No. 6,437,193 B1 as being useful for the oxidation of propylene to acrolein. This patent is incorporated herein by reference.

[0061] The catalyst may comprise an oxidation catalyst represented by the formula

$$Bi_bMo_cV_vA_aD_dE_eO_x$$

[0062] wherein A is one or more of K, Na, Li, Cs and Tl; D is one or more of Fe, Ni, Co, Zn, Ce or La; E is one or more of W, Nb, Sb, Sn, P, Cu, Pb, B, Mg, Ca or Sr; a, d and e are each 0 to 10; b is 0.1 to 10; c is 0.1 to 20; v is 0.1 to 10; c:b is from 2:1 to 30:1; v:b is from 1.5 to 8:1; and x is determined by the frequency and the valence of the elements other than oxygen in the above formula. This catalyst is disclosed in U.S. Pat. No. 5,198,580 as being useful for the conversion of propane to acrylic acid, propylene, acrolein and acetic acid.

[0063] The catalyst may comprise an oxidation catalyst represented by the formula

$$M^1{}_aMo_{1-b}M^2{}_bO_x$$

[0064] where M^1 is Co, Ni, Mg, Zn, Mn and/or Cu; M^2 is W, V, Te, Nb, P, Cr, Fe, Sb, Ce, Sn and/or La; a is from 0.5 to 1.5, b is from 0 to 0.5; and x is a number which is determined by the valency and frequency of the elements other than oxygen. These catalysts are disclosed in U.S. Pat. Nos. 6,388,129 B1; 6,423,875 B1; and 6,426,433 B1 as being useful for the conversion of propane to acrolein and/or acrylic acid. These patents are incorporated herein by reference.

[0065] The catalyst may comprise an oxidation catalyst represented by the formula

$$A_aB_bC_cCa_dFe_eBi_fMo_{12}O_x$$

[0066] where A is one or more of Li, Na, K, Rb or Cs; B is one or more of Mg, Sr, Mn, Ni, Co or Zn; C is one or more of Ce, Cr, Al, Sb, P, Ge, Sn, Cu, V or W; a is 0.01 to 1.0; b and e are 1.0 to 10; c is 0 to 5.0, and in one embodiment 0.05 to 5.0, and in one embodiment 0.05 to 4.0; d and f are 0.05 to 5.0; and x is a number determined by the valence requirements of the other elements present. These catalysts are disclosed in U.S. Pat. No. 6,268,529 B1 as being useful for the conversion of propane to acrolein and acrylic acid. This patent is incorporated herein by reference.